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(19) 日本国特許庁 (JP)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平11-251131

(43) 公開日 平成11年(1999)9月17日

(51) Int.Cl.<sup>a</sup>  
H 01 F 1/20  
B 22 F 3/00  
// B 22 F 1/02

識別記号

F I  
H 01 F 1/20  
B 22 F 3/00  
1/02

B  
E

審査請求 未請求 請求項の数4 O.L (全7頁)

(21) 出願番号 特願平10-49124

(22) 出願日 平成10年(1998)3月2日

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(54) 【発明の名称】 高周波用圧粉磁心及びその製造方法

(57) 【要約】

【課題】 固有抵抗  $2\Omega \text{cm}$  以上で、鉄損をより低くした理想的な圧粉磁心構成及びその製造方法を実現する。

【解決手段】 磷酸塩化成処理液により表面に絶縁被膜を形成した金属磁性粉末と、熱硬化性樹脂粉末とを用いた圧粉磁心において、金属磁性粉末の表面に形成した前記絶縁被膜の膜厚が  $10\text{nm}$  以上、 $100\text{nm}$  以下であると共に、圧粉磁心は、容積比で 84% 以上の前記金属磁性粉末と、1重量% 以上の熱硬化性樹脂からなり、得られる固有抵抗が  $2\Omega \text{cm}$  以上に形成されている構成である。

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## 【特許請求の範囲】

【請求項1】 磷酸塩化成処理液により表面に絶縁被膜を形成した金属磁性粉末と、熱硬化性樹脂とを用いた圧粉磁心において、

前記金属磁性粉末の表面に形成した前記絶縁被膜の膜厚が10nm以上、100nm以下であると共に、圧粉磁心は、容積比で84%以上の前記金属磁性粉末と、1重量%以上の熱硬化性樹脂からなり、得られる固有抵抗が2Ωcm以上であることを特徴とする高周波用圧粉磁心。

【請求項2】 界面活性剤を含む磷酸塩化成処理液により表面に絶縁被膜を形成した金属磁性粉末と、熱硬化性樹脂とを混合した後、圧縮成形すると共に加熱硬化する圧粉磁心の製造方法において、

前記金属磁性粉末として、使用金属磁性粉末の80重量%以上が前記絶縁被膜を10nm以上、100nm以下の膜厚に形成したものを使い、

混合条件として、前記熱硬化性樹脂1重量%以上を前記金属磁性粉末と混合し、成形条件として、前記金属磁性粉末の圧粉磁心中の容積比を84%以上になるよう調整することにより、固有抵抗が2Ωcm以上の圧粉磁心を得ることを特徴とする高周波用圧粉磁心の製造方法。

【請求項3】 前記熱硬化性樹脂として、平均粒径が100μm以下の熱硬化性樹脂粉末を、前記金属磁性粉末に対し1～3重量%の範囲で添加する請求項2に記載の高周波用圧粉磁心の製造方法。

【請求項4】 前記金属磁性粉末と前記熱硬化性樹脂粉末との混合を、通常粉末冶金法で用いられるV型やWコーン型混合機を用い、回転数が15～35rpmの条件下、少なくとも45分以上混合する請求項3に記載の高周波用圧粉磁心の製造方法。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、変圧器、リアクトル、サイリスタバルブ、ノイズフィルタ、チョークコイル等の高周波用として好適な圧粉磁心及びその製造方法に関する。

## 【0002】

【従来の技術】高周波用コイルに用いられる磁心は、低鉄損であり、かつ、高磁束密度であることに加え、これらの磁気特性が高周波領域(1～10MHz)においても低下しないことが要求される。鉄損には磁心の固有抵抗と関係の大きい渦電流損と、鉄粉の製造の過程およびその後のプロセス履歴から生じる鉄粉内の歪みに影響を受けるヒステリシス損がある。そして、この鉄損Wは次式1のように渦電流損とヒステリシス損の和で示すことができる。式1中、fは周波数、Bmは励磁磁束密度、ρは固有抵抗値、tは材料の厚み、k<sub>1</sub>、k<sub>2</sub>は係数である。

## 【0003】

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$$W = (k_1 B m^2 t^2 / \rho) f^2 + k_2 B m \\ 1.6 f$$

【0004】渦電流損は式1により、周波数の二乗に比例して大きくなり、高周波での特性を向上するためには渦電流損を下げなければならない。渦電流損を下げるには渦電流を小領域に閉じこめる必要があり、磁性粉を圧縮により成形し、かつ、個々の磁性粉粒子が絶縁された構成の圧粉磁心とすると効果が高い。このような圧粉磁心でも、絶縁が不十分であると渦電流損が大きくなる。

10 絶縁被膜を厚くすると磁心中の磁性粉の占める割合が下がり、磁束密度が低下する。この磁束密度を圧粉磁心の密度を上げて向上するとなると、高圧下での圧縮成形となって成形時の歪みが避けられず、ヒステリシス損が大きくなり、鉄損の増大を招くことになる。したがって、圧粉磁心の製作には、密度を下げることなく、磁心の固有抵抗を上げることが重要となる。そのためには薄くて、かつ、絶縁性の良好な絶縁被膜で粉末を覆うことが必須となる。

【0005】以上の磁性粉の絶縁被膜に関しては、より薄い絶縁被膜を形成する方法として、本願出願人が先に開発した特願平8-133239号記載のものがある。この方法は、化学反応により絶縁被膜を形成する場合、磷酸塩化成処理液を改良すると共にその処理液に界面活性剤を入れて表面張力を下げ、該処理液と磁性粉の濡れ性を向上することにより、磁性粉表面に対し良質な絶縁被膜をより薄く均一に形成可能にしたものである。そして、絶縁被膜を形成した金属磁性粉末は、通常、エポキシ樹脂等の熱硬化性樹脂と混合され、金型で圧縮成形されると共に加熱硬化されて圧粉磁心に製作される。

## 【0006】

【発明が解決しようとする課題】このように圧粉磁心は、絶縁被膜で覆われた金属磁性粉末を熱硬化性樹脂の結着力により所定の強度に形成されるが、その場合、前記開発された方法により絶縁された金属磁性粉末を用いても、使用樹脂量等により鉄損Wや固有抵抗ρの値が大きく変わる。本出願人はこの圧粉磁心の鉄損Wと固有抵抗ρの間の関係について調査し、鉄損Wと固有抵抗ρの間に図1に示す関係があることを見出した。すなわち、樹脂の成分組成、配合量および絶縁被膜の成分組成を一定にし、絶縁被膜の膜厚を変化させたり、絶縁層形成処理時の乾燥時間を短縮して、故意に錆を発生させて一部の絶縁被膜を破壊させたりと、様々な条件で作製した圧粉磁心の鉄損と固有抵抗とを測定したところ、圧粉磁心の製造条件に関係なく図1に示す曲線の関係になることが得られたわけである。したがって、鉄損を低く抑制するためには、固有抵抗が2Ωcm以上であればよいことが分かる。このため、高性能化を図る上では、絶縁被膜の厚さ、金属磁性粉末と熱硬化性樹脂の配合比率等の成形条件の設定が重要となり、適正な磁束密度で、鉄損を

40 より低くする上では更なる的確な圧粉磁心構成、製法の

条件設定及びその解説が求められている。

【0007】本発明の目的は、特に、高周波用圧粉磁心の固有抵抗を $2\Omega\text{ cm}$ 以上にすることで鉄損が低い理想的な圧粉磁心構成及びその製造方法を提供することにある。

#### 【0008】

【課題を解決するための手段】上記目的を達成するため本発明者らは、先の開発（特願平8-133239号等）方法を適用した絶縁被膜付きの金属磁性粉末を使用して、特に、固有抵抗に及ぼす様々な因子の影響を解明すべく検討する過程で、金属磁性粉末表面の絶縁被膜の膜厚、使用金属磁性粉末の容積比の観点から調整すると、圧粉磁心の鉄損をより低く性能的に向上できることを知見し、完成されたものである。すなわち、本発明の圧粉磁心は、燐酸塩化成処理液により表面に絶縁被膜を形成した圧粉磁心用金属磁性粉末と、熱硬化性樹脂とを用いたものであり、前記金属磁性粉末が前記絶縁被膜を $10\text{ nm}$ 以上、 $100\text{ nm}$ 以下の膜厚に処理したものからなり、圧粉磁心が、容積比で $84\%$ 以上の前記金属磁性粉末と、 $1\text{ 重量\%}$ 以上の熱硬化性樹脂からなり、かつ固有抵抗 $2\Omega\text{ cm}$ 以上に形成されている。また、本発明の製造方法は、界面活性剤を含む燐酸塩化成処理液により表面に絶縁被膜を形成した金属磁性粉末と、熱硬化性樹脂とを混合した後、圧縮成形すると共に加熱硬化する圧粉磁心の製造方法において、前記金属磁性粉末として、使用金属磁性粉末の $80\text{ 重量\%}$ 以上が前記絶縁被膜を $10\text{ nm}$ 以上、 $100\text{ nm}$ 以下の膜厚に形成したものを使い、混合条件として前記熱硬化性樹脂粉末 $1\text{ 重量\%}$ 以上を前記金属磁性粉末と混合し、成形条件として、前記金属磁性粉末の圧粉磁心中の容積比を $84\%$ 以上になるよう調整することにより、固有抵抗が $2\Omega\text{ cm}$ 以上の圧粉磁心を得るものである。

#### 【0009】

【発明の実施の形態】本発明で使用される圧粉磁心用金属磁性粉末は、特願平8-133239号に記載されているように、燐酸塩化成処理液（燐酸、ほう酸、マグネシウムイオンを主とするもので、溶媒である水等に所定の混合率で溶かすと共に界面活性剤を $0.01\sim 1\text{ 重量\%}$ の範囲で混入したもの）により金属磁性粉末（純鉄以外に、Fe-Si合金やFe-Al合金等の鉄系磁性合金粉末）の表面に絶縁被膜を形成したものである。熱硬化性樹脂粉末としては、エポキシ樹脂、フェノール樹脂、ポリアミド樹脂等が従来と同様に使用される。そして、本発明では、前記絶縁被膜を形成した金属磁性粉末と、熱硬化性樹脂粉末とを混合した後、圧縮成形すると共に加熱硬化するが、その際、成形条件として次のようなことが重要項目となる。なお、熱硬化性樹脂は、通常、樹脂粉末の状態で金属磁性粉末と混合されるが、それに限らず、樹脂粉末を溶媒に溶かした状態で金属磁性粉末と混合してもよいものである。

【0010】第1に、用いられる金属磁性粉末として、形成される絶縁被膜が $10\sim 100\text{ nm}$ の膜厚、より好ましくは $30\sim 60\text{ nm}$ の膜厚に形成されたものである。これは、後述する如く絶縁被膜の膜厚が $10\text{ nm}$ 以上のものを用いると、磁束密度を維持して固有抵抗を $2\Omega\text{ cm}$ 以上にことができ、また、金属磁性粉末に形成された絶縁被膜の膜厚の増加に伴って固有抵抗が増加するが、 $100\text{ nm}$ を越えると固有抵抗の増加率が減少すること、膜厚の増加にしたがい圧粉磁心中の金属磁性粉末の含める割合（容積比）が小さくなつて、圧粉磁心の磁束密度を適正值に維持できなくなることに基づいている（図2、図3参照）。また、このように、上記の膜厚に形成した金属磁性粉末を $100\%$ 用いることが最も好ましいが、前記した値の膜厚に形成した金属磁性粉末は、 $80\text{ 重量\%}$ 以上、より好ましくは $90\text{ 重量\%}$ 以上の比率であつてもよい。これは、磁束密度を低下することなく固有抵抗 $2\Omega\text{ cm}$ 以上を同様に維持できることが判明したことに基づいている（図4）。このような試験結果から、本発明は金属磁性粉末として、絶縁被膜を $10\text{ nm}$ 以上、 $100\text{ nm}$ 以下の膜厚に形成したものを、使用する金属磁性粉末の $80\text{ 重量\%}$ 以上の比率で用いることが要件となる。

【0011】第2に、金属磁性粉末の圧粉磁心中の容積比を $84\%$ 以上になるよう調整することである。これは、上記値の膜厚に形成した絶縁被膜付き金属磁性粉末を用いる場合、その絶縁被膜の膜厚、熱硬化性樹脂（粉末）の添加量、圧縮圧力等により金属磁性粉末の容積比が変わるが、その場合の基準となるものであり、上記成形条件にて作製された圧粉磁心試料について、固有抵抗と鉄損の関係、磁束密度に及ぼす金属磁性粉末の密度又は容積比の影響を調べた結果に基づいている（図1）。また、圧粉磁心としては、樹脂量が最低 $1\text{ 重量\%}$ ないと固有抵抗値が $2\Omega\text{ cm}$ 以上を満足できないこと（図5）から、使用する熱硬化性樹脂（粉末）に応じて金属粉末の圧粉磁心中の容積比の上限が定まる。

【0012】第3に、熱硬化性樹脂として熱硬化性樹脂粉末を用いる場合、使用樹脂粉末の平均粒径が $100\mu\text{m}$ 以下のものを、 $1\sim 3\text{ 重量\%}$ の範囲で添加することである。樹脂粉末の添加量は、少なすぎると強度的に不足し難くなり、また、金属磁性粉末同士が接触すると絶縁被膜が薄いため、絶縁が完全には為されず、圧粉磁心の固有抵抗が低下することになる。一方、添加量を多くするほど圧粉磁心の固有抵抗が増加するが、圧粉磁心中の金属磁性粉末の含める割合（容積比）が小さくなり、圧粉磁心の磁束密度が低下することになる。添加量として $1\sim 3\text{ 重量\%}$ の値は試験からも好適であり（図5）、特に、上限が従来よりも低くなっている。また、樹脂粉末の添加量が同じ圧粉磁心であつても、固有抵抗が使用樹脂粉末の平均粒径（粒度）により大きく変動する。具体的には、上記した膜厚の絶縁被膜を形成した金属磁性粉

末を用いた場合、使用樹脂粉末として大きな粒度（平均粒径）のものほど固有抵抗が小さくなり、粒径が $100\text{ }\mu\text{m}$ よりも大きなものを用いると、固有抵抗が $2\Omega\text{ cm}$ よりも小さくなってしまう（図6）。これは、大きな粒度の熱硬化性樹脂粉末を用いると、熱硬化性樹脂粉末が均一に分散されず、金属磁性粉末同士が接触する部分ができる、せっかく絶縁被膜を形成しても、絶縁が完全に行われない部分が発生するからである。一方、粒度の小さい熱硬化性樹脂粉末を用いると、樹脂が金属磁性粉末の周囲を完全に覆い絶縁が完全に為されるからである。

【0013】第4に、通常粉末冶金法で用いられるV型やWコーン型混合機を用いて金属磁性粉末と熱硬化性樹脂粉末とを混合する場合は、回転数が $15\sim35\text{ rpm}$ の条件で、少なくとも45分以上、好ましくは60分以上混合することである。これは混合時間45分以上で作製される圧粉磁心が固有抵抗 $2\Omega\text{ cm}$ 以上になるが、これ以下の混合時間では $2\Omega\text{ cm}$ の固有抵抗を得ることができないことによる（（図7）。この混合時間は、従来の常識よりかなり長い時間であり、混合時間が長くなると二次凝集した熱硬化性樹脂粉末が適度に粉碎されて、金属磁性粉末により均一に混合されることに起因しており、45分に満たない混合時間では二次凝集粉末の粉碎が完全には為されず残留する結果、大きな粒径の熱硬化性樹脂粉末を用いた場合と等しく、金属磁性粉末と熱硬化性樹脂粉末の分散が完全には為されず金属磁性粉末同士が接触し、絶縁が不完全な部分ができるからである。また、120分を超えて混合しても、二次凝集粉末の粉碎が完了し、金属磁性粉末と熱硬化性樹脂粉末が均一に分散した後は、長く混合しても意味はなく、いたずらに時間とエネルギーを費やすのみなので効果はない。

#### 【0014】

【実施例】以下の各実施例で作製された圧粉磁心（試料）は、成形条件として次の点で共通している。金属磁性粉末としては平均粒径が $70\text{ }\mu\text{m}$ のアトマイズ球状鉄粉を用いた。磷酸塩化成処理液は、水1リットルに磷酸20g、ホウ酸4g、金属酸化物としてMgOを4g溶解し、界面活性剤としてEF-104（トーケミプロダクト製）を用い、防錆剤としてベンゾトリアゾール0.04molを加えたものである。絶縁被膜の形成は、前記金属磁性粉末と前記磷酸塩化成処理液とを容器に入れ、定時間混合した後、恒温槽を用いて $180^\circ\text{C}$ で60分間乾燥した。絶縁被膜の厚さは、金属磁性粉末に対する磷酸塩化成処理液の添加量を変えることにより調整し、膜厚が異なる複数のものを作り使用した。これに対し、熱硬化性樹脂粉末としては何れもポリアミド樹脂を使用した。

【0015】金属磁性粉末と熱硬化性樹脂粉末との混合には、V型混合機を使用し、回転数 $25\text{ rpm}$ の設定を行った。圧縮成形では、金属磁性粉末と熱硬化性樹脂粉末との混合物を金型に充填し、 $500\text{ MPa}$ の圧力で圧

縮成形した。加熱処理は $200^\circ\text{C}$ で、4時間硬化した。これらは何れの試料の圧粉磁心でも同じである。また、鉄損の測定は $15\text{ kHz}$ ,  $0.05\text{ T}$ で行い、磁束密度の測定は $50\text{ Hz}$ ,  $30\text{ kA/m}$ で行った。また、容積比については、上記条件より求まる重量比を理論密度により容積比に換算して行い、膜厚についてはさらに、鉄粉の表面積より計算した理論膜厚値を用いた。

【0016】（実施例1）上記絶縁被膜付きの金属磁性粉末を用い、上記成形条件及び段落0006に記載した10条件にて作製された圧粉磁心試料について、固有抵抗と鉄損の関係、磁束密度に及ぼす金属磁性粉末の密度や容積比の影響を調べた。このときの試験結果を図1, 2に示す。各試料である圧粉磁心は、上記成形条件において、使用金属磁性粉末として膜厚の異なる絶縁被膜に形成されたものを使用し、それ以外（溶媒、使用熱硬化性樹脂粉末及び添加量、混合条件、圧縮圧力等）を全て同じ条件で作製したものサンプリングしたものである。図1は各試料について、固有抵抗と鉄損とを測定した値をグラフにプロットし、図2は図1に使用した試料のうち、6つの試料を選んで磁束密度を測定し、その値と金属磁性粉末の密度及び容積比をグラフにプロットしたものである。

【0017】実施例1からは、先に開発した方法で絶縁被膜を形成した金属磁性粉末を用いた圧粉磁心の場合、図1のように、鉄損W（W/kg）が固有抵抗 $2\Omega\text{ cm}$ よりも小さくなると急速に高くなり、逆に固有抵抗 $2\Omega\text{ cm}$ 以上になると低くかつ安定した値になると、図2のように、磁束密度B（T）が使用金属磁性粉末の容積比（%）に比例して大きくなるが、その場合、磁束密度B（T）として0.8以上にするには金属磁性粉末の容積比を84%以上にしなければならないことが分かる。これらは、適正な磁束密度で、低鉄損である理想的な圧粉磁心を実現する上で、その磁心構成及び成形条件を決める際の目安を示唆するものである。

【0018】（実施例2）上記成形条件にて作製された40圧粉磁心試料について、固有抵抗に及ぼす絶縁被膜の厚さの影響と、密度や金属磁性粉末の容積比に及ぼす絶縁被膜の厚さの影響を調べた。このときの試験結果を図3に示す。各試料である圧粉磁心は、上記成形条件において、図1の実施例と同様に使用金属磁性粉末として膜厚の異なる絶縁被膜に形成されたもの（絶縁被膜のないものも含む）を使用し、それ以外（溶媒、使用熱硬化性樹脂粉末及び添加量、混合条件、圧縮圧力等）を全く同じ条件で作製したものである。図3（a）は各試料について、絶縁被膜の膜厚とその固有抵抗を代表的なもののみグラフにプロットし、図3（b）は全試料について絶縁被膜の膜厚とその密度及び金属磁性粉末の容積比をグラフにプロットしたものである。

【0019】この試験例からは、図3（a）のように、50膜厚が0つまり絶縁被膜がない金属磁性粉末を用いたも

のと、絶縁被膜を形成した金属磁性粉末を用いたものは固有抵抗が明瞭に区別され、固有抵抗 $2\Omega\text{cm}$ 以上にするには絶縁被膜の厚さが $10\text{nm}$ 以上のものを用いなければならぬことと、絶縁被膜の厚さが約 $100\text{nm}$ 以上になると固有抵抗の増加率が減少し、しかも図3(b)のように金属磁性粉末の容積比が8.4%以下になり上記した磁束密度も低下することが分かる。これらは、適正な磁束密度で、低鉄損である理想的な圧粉磁心を得る上で、使用金属磁性粉末として、絶縁被膜の膜厚 $10\text{nm}$ 以上、 $100\text{nm}$ 以下のものが最も好ましいことを示している。

【0020】(実施例3) 実施例3は実施例2の変形であり、固有抵抗に及ぼす金属磁性粉末の未絶縁部の比率の影響を調べたときの一例である。各試料である圧粉磁心は、上記成形条件において、使用金属磁性粉末として上記絶縁被膜の膜厚が $30\text{nm}$ に形成されたものに、絶縁被膜を形成しないものを異なる比率(重量%)で混ぜ、それ以外(溶媒、使用熱硬化性樹脂粉末及び添加量、混合条件、圧縮圧力等)を全く同じ条件で作製したものである。このときの試験結果を図4に示す。この試験例からは、固有抵抗 $2\Omega\text{cm}$ 以上を維持する上で、上記絶縁被膜付きの金属磁性粉末を必ずしも百%にする必要がなく、少なくとも80重量%の比率で用いればよいことが分かる。

【0021】(実施例4) 実施例4は、固有抵抗に及ぼす熱硬化性樹脂粉末の添加量(以下、樹脂量と略称する)の影響と、密度や金属磁性粉末の容積比が及ぼす絶縁被膜の厚さの影響を調べたときの一例である。各試料である圧粉磁心は、上記成形条件において、使用金属磁性粉末として絶縁被膜の膜厚が $30\text{nm}$ に形成されたものを使用し、使用樹脂量を $0\sim3.5$ 重量%の範囲で変えて、それ以外(溶媒、使用熱硬化性樹脂粉末、混合条件、圧縮圧力等)を全く同じ条件で作製したものである。このときの試験結果を図5に示す。図5(a)は各試料について、樹脂量とその固有抵抗をグラフにプロットし、図5(b)はそれについて樹脂量とその密度及び金属磁性粉末の容積比をグラフにプロットしたものである。

【0022】この試験例からは、図5(a)のように、樹脂量が0つまり熱硬化性樹脂粉末を添加しない圧粉磁心(単に圧縮により形状保持されている圧粉磁心)と、例えば0.5重量%添加した圧粉磁心では固有抵抗が大きく異なり、固有抵抗 $2\Omega\text{cm}$ 以上にするには少なくとも1重量%の樹脂量を添加しなければならないことと、図5(b)のように3重量%の樹脂量を添加すると金属磁性粉末の容積比が8.4%以下になり上記した磁束密度も低下することが分かる。これらは、適正な磁束密度で、低鉄損である理想的な圧粉磁心を得る上で、使用熱硬化性樹脂粉末として、1~3重量%の範囲で添加することが最も好ましいことを示している。なお、樹脂量が

1重量%以上であることから強度的にも充足される。

【0023】(実施例5) 実施例5は実施例4の変形であり、固有抵抗に及ぼす熱硬化性樹脂粉末の粒径の影響を調べたときの一例である。各試料である圧粉磁心は、上記成形条件において、熱硬化性樹脂粉末として、その平均粒径が $10, 20, 30, 50, 100, 200, 300$ および $500\mu\text{m}$ のものを用い、それら粒径別に上記絶縁被膜の膜厚が $30\text{nm}$ に形成された金属磁性粉末に混ぜ、それ以外(溶媒、使用熱硬化性樹脂粉末及び添加量、混合条件、圧縮圧力等)を全く同じ条件で作製したものである。このときの試験結果を図6に示す。この試験例からは、固有抵抗 $2\Omega\text{cm}$ 以上を維持する上で、同じ熱硬化性樹脂粉末であっても、その樹脂粉末の粒度(平均粒径)の相違により固有抵抗が大きく変わることと、 $2\Omega\text{cm}$ 以上を維持する上で、少なくとも平均粒径 $100\mu\text{m}$ 以下という微細なものが好適であると言える。

【0024】(実施例6) 実施例6は固有抵抗に及ぼす混合時間の影響を調べたときの一例である。各試料である圧粉磁心は、上記成形条件において、上記絶縁被膜付きの金属磁性粉末と熱硬化性樹脂粉末とを混合する場合、V型混合機を用いて、混合時間を除いて全く同じ条件で作製したものである。このときの試験結果を図7に示す。この試験例からは、混合時間が60分になるまで固有抵抗が大きく変わることと、固有抵抗 $2\Omega\text{cm}$ 以上を維持する上で、少なくとも40分以上という長い時間にわたって混合しなければならないことが分かる。このような、混合時間の影響については、試験過程で知見したものであり、製造上、次に述べる理由により極めて重要な成形条件となる。すなわち、粉末冶金関係においては、V型混合機やWコーン型混合機等を用いて原材料を混合する場合、通常、回転数 $15\sim35\text{rpm}$ の設定で、必要とされる混合時間が長くて20分であり、製造上の誤差を見込んでも30分以内が常識となっている。ところが、上記した絶縁被膜付きの金属磁性粉と熱硬化性樹脂粉末とを混合し、圧縮及び加熱硬化して圧粉磁心を作製する場合、混合時間を従来の粉末冶金法によるものよりも長くする必要があるからである。

【0025】

【発明の効果】以上説明したように、本発明の圧粉磁心は、均一で良質な絶縁被膜を形成した金属磁性粉末を用いている磁心構成において、適正な磁束密度で、固有抵抗 $2\Omega\text{cm}$ 以上、すなわち低鉄損であるという高性能化が達成される。また、本発明の製造方法は、従来に比してより的確な成形条件を解明したことから、高性能の圧粉磁心を確実かつ安定して量産することが可能となる。

【図面の簡単な説明】

【図1】本発明を完成する上で、固有抵抗と鉄損との関係を調べたときのグラフである。

【図2】本発明を完成する上で、磁束密度に及ぼす金属

磁性粉末の容積比の影響を調べたときのグラフである。

【図3】本発明において、固有抵抗に及ぼす絶縁被膜の厚さの影響、並びに金属磁性粉末の容積比に及ぼす絶縁被膜の厚さの影響を調べたグラフである。

【図4】本発明において、固有抵抗に及ぼす金属磁性粉末の未絶縁部の比率の影響を調べたグラフである。

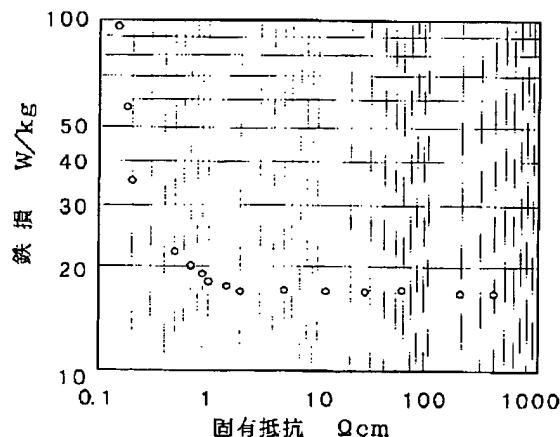
【図5】本発明において、固有抵抗に及ぼす樹脂量の影

響、並びに金属磁性粉末の容積比に及ぼす樹脂量の影響を調べたグラフである。

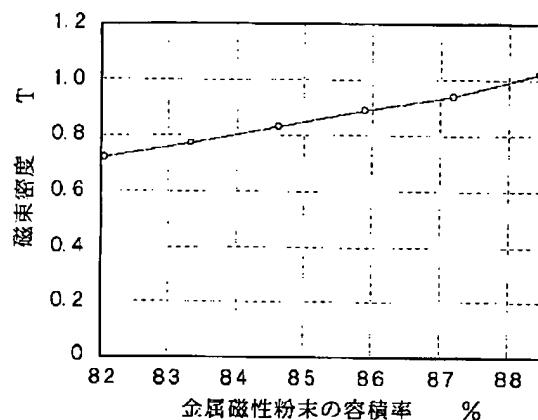
【図6】本発明において、固有抵抗に及ぼす樹脂粉末の粒度（平均粒径）の影響を調べたグラフである。

【図7】本発明において、固有抵抗に及ぼす混合時間の影響を調べたグラフである。

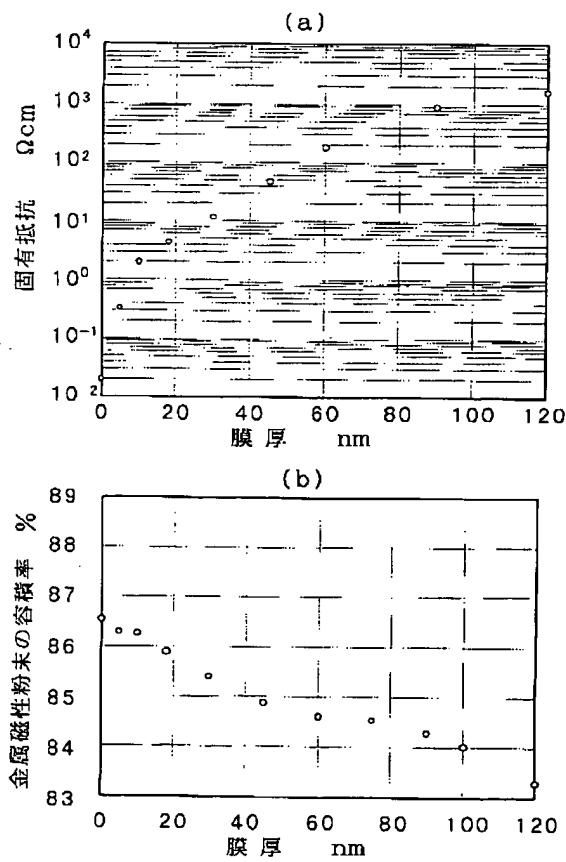
【図1】



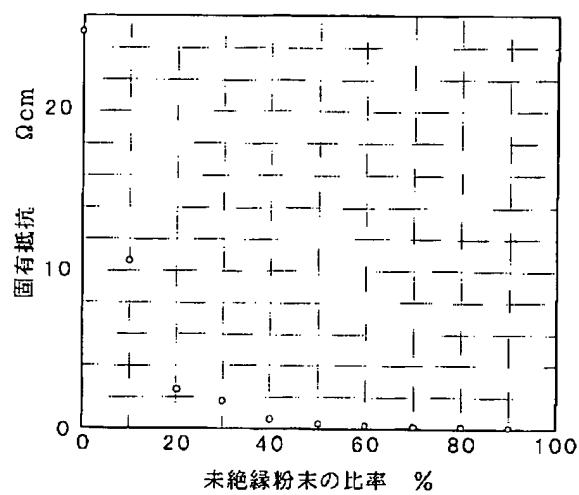
【図2】



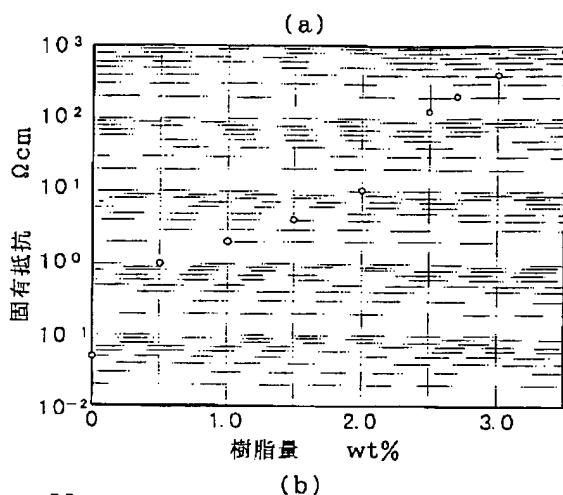
【図3】



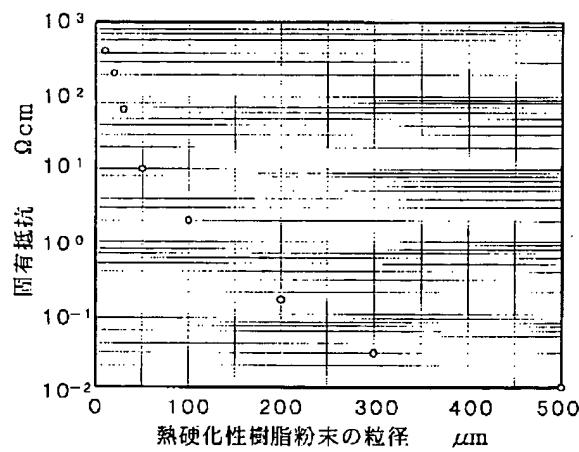
【図4】



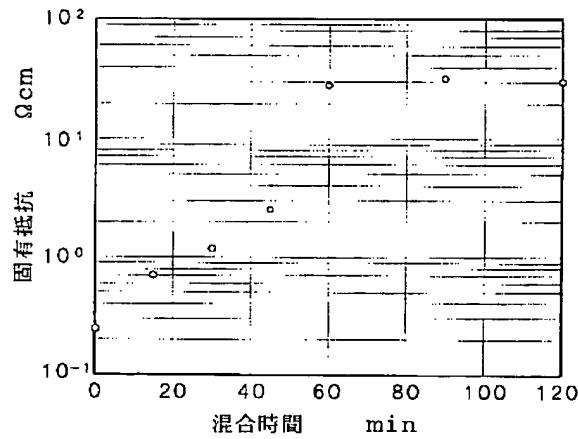
【図5】



【図6】



【図7】



## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-251131

(43)Date of publication of application : 17.09.1999

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(51)Int.Cl. H01F 1/20  
B22F 3/00  
// B22F 1/02

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(21)Application number : 10-049124 (71)Applicant : HITACHI POWDERED METALS  
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(22)Date of filing : 02.03.1998 (72)Inventor : ISHIHARA YUKINARI  
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### (54) DUST CORE FOR HIGH FREQUENCY AND ITS MANUFACTURE

#### (57)Abstract:

PROBLEM TO BE SOLVED: To provide an ideal dust core constitution having a specific resistance of larger than or equal to  $2 \Omega \text{ cm}$  and a further reduced iron loss, and a method for manufacturing the dust core.

SOLUTION: A dust core is manufactured by the use of magnetic metal powder coated with insulating films formed through chemical conversion coating, using a phosphate and a thermosetting resin powder. The thickness of the insulating films coating the metal powder is adjusted to 10-100 nm, and the dust core contains the metal powder at a rate higher than or equal to 84 vol.% and the thermosetting resin powder at a rate higher than or equal to  $\geq 1$  wt.%, so that the specific resistance of the dust core is formed larger than or equal to  $2 \Omega \text{ cm}$ .

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### LEGAL STATUS

[Date of request for examination] 09.08.2001

[Date of sending the examiner's decision of  
rejection]

[Kind of final disposal of application other than  
the examiner's decision of rejection or  
application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's  
decision of rejection]

[Date of requesting appeal against examiner's  
decision of rejection]

[Date of extinction of right]

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## DETAILED DESCRIPTION

### [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to a dust core suitable as objects for RFs, such as a transformer, a reactor, a thyristor bulb, a noise filter, and a choke coil, and its manufacture method.

[0002]

[Description of the Prior Art] In addition to the core used for the coil for RFs being low iron loss, and being high flux density, it is required that those magnetic properties should not fall in a RF field (1-10MHz). There is hysteresis loss which receives influence in the distortion in the iron powder produced from the process of the specific resistance of a core, the large eddy current loss of a relation, and manufacture of iron powder and a subsequent process history in iron loss. And the sum of an eddy current loss and hysteresis loss can show this iron loss W like the following formula 1. For frequency and Bm, the thickness of material, and k1 and k2 are [ f / excitation flux density and rho of a specific resistance value and t ] coefficients among a formula 1.

[0003]

[Formula 1]  $W = (k_1 B_m^2 t^2 / \rho) f^2 + k_2 B_m^1.6f$  [0004] An eddy current loss must lower an eddy current loss, in order to become large in proportion to the square of frequency and to improve the property in a RF by the formula 1. An effect is high when it is the dust core of composition of that needed to confine the eddy current in the small field for lowering an eddy current loss, and fabricated magnetic powder by compression and each magnetic powder particle was insulated. An eddy current loss becomes it large that such a dust core of an insulation is also inadequate. If an insulating coat is thickened, the rate for which the magnetic powder in a core accounts will fall, and flux density will fall. When raising the density of a dust core for this flux density and improving, it becomes compression molding under high pressure, and the distortion at the time of fabrication is not avoided, but hysteresis loss becomes large and will cause increase of iron loss. Therefore, it becomes important to raise the specific resistance of a core, without lowering density to manufacture of a dust core. It becomes indispensable to cover powder with a good insulating insulating coat thinly for that purpose.

[0005] About the insulating coat of the above magnetic powder, there is a thing given in Japanese Patent Application No. No. 133239 [ eight to ] which the applicant for this patent developed previously as a method of forming a thinner insulating coat. This method puts a surfactant into the processing liquid, lowers surface tension while it improves phosphate chemical-conversion liquid, when forming an insulating coat according to a chemical reaction, and by improving the wettability of this processing liquid and magnetic powder, to a magnetic powder front face, it is thinner and it enables formation of a good insulating coat uniformly. And heat hardening of it is carried out and the metal magnetism powder in which the insulating coat was formed is manufactured by the dust core while being mixed with thermosetting resin, such as an epoxy resin, and usually pressing it with metal mold.

[0006]

[Problem(s) to be Solved by the Invention] Thus, although the binding capacity of thermosetting resin

forms in predetermined intensity the metal magnetism powder covered with the insulating coat, even if the metal magnetism powder insulated by the method by which development was carried out [ aforementioned ] in that case is used for a dust core, it changes the value of iron loss W and specific resistance rho a lot with the amount of use resins etc. These people investigated about the relation between the iron loss W and specific resistance rho of this dust core, and it found out that the relation between iron loss W and specific resistance rho shown in drawing 1 was. Namely, fix component composition of component composition of a resin, loadings, and an insulating coat, and change the thickness of an insulating coat or the drying time at the time of insulating stratification processing is shortened. The bird clapper was obtained by the relation of the curve shown in drawing 1 regardless of the manufacture conditions of a dust core when the iron loss and specific resistance of a dust core which were made to generate rust intentionally and were produced on various conditions as it is as making some insulating coats destroy \*\*\*\* were measured. Therefore, in order to suppress iron loss low, things are understood that specific resistance should just be more than 2-ohmcm. For this reason, when attaining highly efficient-ization, a setup of process conditions, such as thickness of an insulating coat and a rate of a compounding ratio of metal magnetism powder and thermosetting resin, becomes important, and when making iron loss lower with proper flux density, the further exact dust core composition, the conditioning of a process, and its elucidation are called for.

[0007] Especially the purpose of this invention has iron loss in offering low ideal dust core composition and its manufacture method by carrying out specific resistance of the dust core for RFs more than 2-ohmcm.

[0008]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention persons are the process examined that the influence of various factors which use the metal magnetism powder with an insulating coat which applied the previous development methods (Japanese Patent Application No. No. 133239 [ eight to ] etc.), and are especially exerted on specific resistance should be solved. If it adjusts from a viewpoint of the thickness of the insulating coat of a metal magnetism powder front face, and the volume ratio of use metal magnetism powder, the knowledge of the ability to improve the iron loss of a dust core efficiently lower will be carried out, and it will be completed. namely, the dust core by which the dust core of this invention formed the insulating coat in the front face with phosphate chemical-conversion liquid -- public funds -- it consists of that to which the aforementioned metal magnetism powder processed the aforementioned insulating coat to thickness (10nm or more and 100nm or less) using group magnetism powder and thermosetting resin, and a dust core serves as 84% or more of the aforementioned metal magnetism powder from 1% of the weight or more of thermosetting resin by the volume ratio, and it is formed more than the specific resistance cm of 2ohms Moreover, the manufacture method of this invention is set to the manufacture method of the dust core which carries out heat hardening while pressing, after mixing the metal magnetism powder which formed the insulating coat in the front face with the phosphate chemical-conversion liquid containing a surfactant, and thermosetting resin. As the aforementioned metal magnetism powder, 80% of the weight or more of use metal magnetism powder the aforementioned insulating coat 10nm or more, The 1 % of the weight or more of the aforementioned thermosetting resin powder is mixed with the aforementioned metal magnetism powder as mixed conditions using what was formed in thickness 100nm or less. as a process condition By adjusting the volume ratio in the dust core of the aforementioned metal magnetism powder so that it may become 84% or more, specific resistance obtains the dust core more than 2-ohmcm.

[0009]

[Embodiments of the Invention] the dust core used by this invention -- public funds -- group magnetism powder It is phosphate chemical-conversion liquid (it is that which is mainly concerned with phosphoric acid, a way acid, and magnesium ion) as indicated by Japanese Patent Application No. No. 133239 [ eight to ]. While melting with predetermined mixing percentage in the water which is a solvent, an insulating coat is formed in the front face of metal magnetism powder (it is in the end of an iron system magnetism alloy powder, such as an Fe-Si alloy and an Fe-aluminum alloy, in addition to pure iron) by what mixed the surfactant in 0.01 - 1% of the weight of the range. As thermosetting resin powder, an

epoxy resin, phenol resin, polyamide resin, etc. are used as usual. And although heat hardening is carried out in this invention while pressing after mixing the metal magnetism powder in which the aforementioned insulating coat was formed, and thermosetting resin powder, the following serves as a critical item as a process condition in that case. In addition, usually, although mixed with metal magnetism powder in the state of resin powder, thermosetting resin is not restricted to it, but where resin powder is melted to a solvent, you may mix it with metal magnetism powder.

[0010] the thickness whose insulating coat formed is 10-100nm as metal magnetism powder used for the 1st -- it is more preferably formed in 30-60nm thickness If the thickness of an insulating coat uses a thing 10nm or more so that it may mention later, although specific resistance will increase with the increase in the thickness of the insulating coat which could maintain flux density, and could carry out specific resistance more than 2-ohmcm, and was formed in metal magnetism powder, this If 100nm is exceeded, the rate of increase of specific resistance decreasing and the rate (volume ratio) which the metal magnetism powder in a dust core includes according to the increase in thickness are based on becoming small and it becoming impossible to maintain the flux density of a dust core to a proper value (refer to drawing 2 and drawing 3 ). Moreover, although it is most desirable to use the metal magnetism powder formed in the above-mentioned thickness 100% in this way, the metal magnetism powder formed in the thickness of said value may be 90% of the weight or more of a ratio more preferably 80% of the weight or more. This is based on what it made clear that more than the specific resistance cm of 2ohms is maintainable similarly, without falling flux density ( drawing 4 ). It becomes requirements from such a test result to use this invention as metal magnetism powder by 80% of the weight or more of the ratio of the metal magnetism powder which uses what formed the insulating coat in thickness (10nm or more and 100nm or less).

[0011] It is adjusting the volume ratio in the dust core of metal magnetism powder to the 2nd so that it may become 84% or more. Although this changes the volume ratio of metal magnetism powder by the thickness of the insulating coat, the addition of thermosetting resin (powder), the compression pressure, etc. when using the metal magnetism powder with an insulating coat formed in the thickness of the above-mentioned value, it serves as the criteria in that case, and is based on the result which investigated the density of the metal magnetism powder exerted on the relation between specific resistance and iron loss, and flux density, or the influence of a volume ratio about the dust core sample produced in the above-mentioned process condition ( drawing 1 ). Moreover, according to the thermosetting resin (powder) to be used, the upper limit of the volume ratio in the dust core of a metal powder becomes settled from the ability of a specific resistance value not to satisfy more than 2-ohmcm as a dust core, unless the amount of resins has at least 1 % of the weight ( drawing 5 ).

[0012] When using [ 3rd ] thermosetting resin powder as thermosetting resin, the mean particle diameter of use resin powder is adding a thing 100 micrometers or less in 1 - 3% of the weight of the range. If there are too few additions of resin powder, it will be hard coming to be sufficient in intensity, and when metal magnetism powder contacts, since the insulating coat is thin, it will not succeed in an insulation completely but the specific resistance of a dust core will fall. On the other hand, although the specific resistance of a dust core increases so that an addition is made [ many ], the rate (volume ratio) which the metal magnetism powder in a dust core includes becomes small, and the flux density of a dust core will fall. As an addition, 1 - 3% of the weight of the value is suitable also from an examination ( drawing 5 ), and it is low infinite from before especially. Moreover, even if the addition of resin powder is the same dust core, specific resistance is sharply changed by the mean particle diameter (grain size) of use resin powder. If specific resistance becomes small and the thing of a big grain size (mean particle diameter) as use resin powder uses what has a bigger particle size than 100 micrometers when the metal magnetism powder which specifically formed the above-mentioned insulating coat of thickness is used, specific resistance will become smaller than 2-ohmcm ( drawing 6 ). This is because the portion into which an insulation is not performed completely will occur even if thermosetting resin powder is not distributed uniformly, but the portion which metal magnetism powder contacts is made and it forms an insulating coat with much trouble, if the thermosetting resin powder of a big grain size is used. It is because a resin will cover the circumference of metal magnetism powder completely and it will succeed in an insulation

completely on the other hand, if thermosetting resin powder with a small grain size is used.

[0013] When mixing metal magnetism powder and thermosetting resin powder using the V type and W cone type mixer which are usually used for the 4th with powder-metallurgy processing, rotational frequencies are the conditions of 15 - 35rpm, and are mixing 60 minutes or more preferably at least 45 minutes or more. This is because specific resistance of 2-ohmcm cannot be obtained in the mixing time not more than this, although the dust core produced more than in mixing time 45 minute becomes more than the specific resistance cm of 2ohms (.). ( drawing 7 ) The thermosetting resin powder which this mixing time was time quite longer than the conventional common sense, and was secondarily condensed when mixing time became long is ground moderately. The result which it originates in being uniformly mixed with metal magnetism powder, and does not succeed in the pulverization in the end of a secondary agglomerated powder completely in the mixing time which is not filled in 45 minutes, but remains, It is because it is equal to the case where the thermosetting resin powder of a big particle size is used, and it does not succeed in distribution of metal magnetism powder and thermosetting resin powder completely, but metal magnetism powder contacts and a portion with an imperfect insulation is made. Moreover, even if it mixes exceeding 120 minutes, after the pulverization in the end of a secondary agglomerated powder is completed and metal magnetism powder and thermosetting resin powder distribute uniformly, even if it mixes for a long time, it is meaningless, and since it is only spending time and energy in vain, it is ineffective.

[0014]

[Example] The dust core (sample) produced in each following example is common the following point as a process condition. As metal magnetism powder, the mean particle diameter used the atomization spherical iron powder which is 70 micrometers. Phosphate chemical-conversion liquid dissolves 4g of MgO(s) in 1l. of water as 20g of phosphoric acid, 4g of boric acids, and a metallic oxide, and adds benzotriazol 0.04mol as a rusr-proofer, using EF-104 (product made from toe KEMIPU loader shoes) as a surfactant. Formation of an insulating coat was dried for 60 minutes at 180 degrees C using the thermostat, after putting the aforementioned metal magnetism powder and the aforementioned phosphate chemical-conversion liquid into the container and mixing during scheduled time. The thickness of an insulating coat was adjusted by changing the addition of the phosphate chemical-conversion liquid to metal magnetism powder, and two or more things from which thickness differs were made and used for it. On the other hand, as thermosetting resin powder, each used polyamide resin.

[0015] The V shaped rotary mixer was used for mixture with metal magnetism powder and thermosetting resin powder, and it carried out to it by setup of rotational frequency 25rpm. The mixture of metal magnetism powder and thermosetting resin powder was filled up with compression molding into metal mold, and was pressed by the pressure of 500MPa with it. Heat-treatment is 200 degrees C and was hardened for 4 hours. These are the same at any dust core of a sample. Moreover, measurement of iron loss was performed by 15kHz and 0.05T, and measurement of flux density was performed by 50Hz and 30 kA/m. Moreover, it carried out by having converted into the volume ratio the weight ratio which can be found from the above-mentioned conditions with theoretical density about the volume ratio, and the theoretical thickness value calculated from the surface area of iron powder was further used about thickness.

[0016] (Example 1) The relation between specific resistance and iron loss, and the density of metal magnetism powder and the influence of a volume ratio affect flux density were investigated using metal magnetism powder with the above-mentioned insulating coat about the dust core sample produced on the conditions indicated in the above-mentioned process condition and the paragraph 0006. The test result at this time is shown in drawing 1 and 2. In the above-mentioned process condition, what was formed in the insulating coat from which thickness differs as use metal magnetism powder is used for the dust core which is each sample, and it samples what was produced on the same conditions other than this [ all ] (a solvent, use thermosetting resin powder and an addition, mixed conditions, compression pressure, etc.). Drawing 1 plots in a graph the value which measured specific resistance and iron loss about each sample, and drawing 2 chooses six samples among the samples used for drawing 1 , measures flux density, and plots the density and the volume ratio of the value and metal magnetism

powder in a graph.

[0017] In the case of the dust core using the metal magnetism powder which formed the insulating coat by the method developed previously, from an example 1 like drawing 1 the value stabilized low [ when it will become high quickly if iron loss W (W/kg) becomes smaller than the specific resistance cm of 2ohms, and it becomes conversely more than the specific resistance cm of 2ohms ] -- a bird clapper -- \*\* -- like drawing 2 , although flux density B (T) becomes large in proportion to the volume ratio (%) of use metal magnetism powder In this case, it turns out that the volume ratio of metal magnetism powder must be made 84% or more for carrying out to 0.8 or more as flux density B (T). These are proper flux density, and when realizing the ideal dust core which is low iron loss, they suggest the standard at the time of deciding the core composition and process condition.

[0018] (Example 2) About the dust core sample produced in the above-mentioned process condition, the influence of the thickness of the insulating coat exerted on specific resistance and the influence of the thickness of the insulating coat exerted on the volume ratio of density metallurgy group magnetism powder were investigated. The test result at this time is shown in drawing 3 . In the above-mentioned process condition, what was formed in the insulating coat from which thickness differs as use metal magnetism powder like the example of drawing 1 (a thing without an insulating coat is also included) is used for the dust core which is each sample, and it produces it on the conditions same other than this (a solvent, use thermosetting resin powder and an addition, mixed conditions, compression pressure, etc.) completely. As for drawing 3 (a), only a typical thing plots the thickness and specific resistance of an insulating coat in a graph about each sample, and drawing 3 (b) plots the volume ratio of the thickness and density of an insulating coat, and metal magnetism powder in a graph about all samples.

[0019] The thing using the metal magnetism powder in which 0, i.e., an insulating coat, does not have thickness like drawing 3 (a) from this example of an examination, For distinguishing specific resistance clearly in the thing using the metal magnetism powder in which the insulating coat was formed, and carrying out more than the specific resistance cm of 2ohms, the thickness of an insulating coat must use a thing 10nm or more, It turns out that the rate of increase of specific resistance will decrease if the thickness of an insulating coat is set to about 100nm or more, and the flux density which the volume ratio of metal magnetism powder became 84% or less, and moreover described above like drawing 3 (b) also falls. These are proper flux density, and when obtaining the ideal dust core which is low iron loss, they show that 10nm or more of thickness of an insulating coat and a thing 100nm or less are the most desirable as use metal magnetism powder.

[0020] (Example 3) An example 3 is deformation of an example 2 and is an example when investigating the influence of the ratio of the non-insulated section of the metal magnetism powder exerted on specific resistance. In the above-mentioned process condition, as use metal magnetism powder, the thickness of the above-mentioned insulating coat mixes the dust core which is each sample by ratio (% of the weight) which is different in what does not form an insulating coat in what was formed in 30nm, and produces it on the conditions same other than this (a solvent, use thermosetting resin powder and an addition, mixed conditions, compression pressure, etc.) completely. The test result at this time is shown in drawing 4 . This example of an examination shows that what is necessary is not to necessarily make 100% metal magnetism powder with the above-mentioned insulating coat, and just to use it by at least 80% of the weight of the ratio when maintaining more than the specific resistance cm of 2ohms.

[0021] (Example 4) An example 4 is an example when investigating the influence of the addition (it being hereafter called the amount of resins for short) of the thermosetting resin powder exerted on specific resistance, and the influence of the thickness of the insulating coat which the volume ratio of density metallurgy group magnetism powder does. In the above-mentioned process condition, as use metal magnetism powder, the thickness of an insulating coat uses what was formed in 30nm, changes the amount of use resins in 0 - 3.5% of the weight of the range, and produces the dust core which is each sample on the conditions same other than this (a solvent, use thermosetting resin powder, mixed conditions, compression pressure, etc.) completely. The test result at this time is shown in drawing 5 . Drawing 5 (a) plots the amount of resins, and its specific resistance in a graph about each sample, and drawing 5 (b) plots the volume ratio of the amount of resins, its density, and metal magnetism powder in

a graph about it.

[0022] The dust core to which the amount of resins does not add 0, i.e., thermosetting resin powder, like drawing 5 (a) from this example of an examination (dust core in which configuration maintenance is only carried out by compression), For example, the thing for which at least 1% of the weight of the amount of resins must be added for specific resistance to differ greatly in the dust core added 0.5% of the weight, and carry out more than the specific resistance cm of 2ohms, When 3% of the weight of the amount of resins is added like drawing 5 (b), it turns out that the flux density which the volume ratio of metal magnetism powder became 84% or less, and described above also falls. These are proper flux density and show that it is most desirable as use thermosetting resin powder to add in 1 - 3% of the weight of the range when obtaining the ideal dust core which is low iron loss. In addition, it is sufficient also in intensity from the amount of resins being 1 % of the weight or more.

[0023] (Example 5) An example 5 is deformation of an example 4 and is an example when investigating the influence of the particle size of the thermosetting resin powder exerted on specific resistance. As thermosetting resin powder, using that the mean particle diameter of whose is 10, 20, 30, 50, 100, 200, 300, and 500 micrometers, the dust core which is each sample is mixed with the metal magnetism powder with which the thickness of the above-mentioned insulating coat was formed according to these particle size at 30nm, and is produced in the above-mentioned process condition on the conditions same other than this (a solvent, use thermosetting resin powder and an addition, mixed conditions, compression pressure, etc.) completely. The test result at this time is shown in drawing 6 . From this example of an examination, when maintaining more than the specific resistance cm of 2ohms, even if it is the same thermosetting resin powder, when maintaining that specific resistance changes a lot by difference of the grain size (mean particle diameter) of the resin powder, and more than 2-ohmcm, it can be said at least that a detailed thing thing called 100 micrometers or less of mean particle diameters is suitable.

[0024] (Example 6) An example 6 is an example when investigating the influence of the mixing time exerted on specific resistance. In the above-mentioned process condition, the dust core which is each sample is produced on the completely same conditions except for mixing time using a V shaped rotary mixer, when mixing metal magnetism powder and thermosetting resin powder with the above-mentioned insulating coat. The test result at this time is shown in drawing 7 . This example of an examination shows that specific resistance changes a lot until mixing time becomes in 60 minutes, and that it must mix over the long time of 40 minutes or more at least when maintaining more than the specific resistance cm of 2ohms. About such influence of mixing time, knowledge is carried out in examination process and it becomes a very important process condition for the reason explained below on manufacture. That is, in the powder metallurgy relation, when mixing raw material using a V shaped rotary mixer, W cone type mixer, etc., the mixing time which is a setup of a rotational frequency 15 - 35rpm, and is usually needed is long, and is 20 minutes, and although the error on manufacture is expected, less than 30 minutes has been common sense. However, it is because the above-mentioned metal magnetism powder and the above-mentioned thermosetting resin powder with an insulating coat are mixed, and it is necessary to make it longer than what depends mixing time on the conventional powder-metallurgy processing compression and when carrying out heat hardening and producing a dust core.

[0025]

[Effect of the Invention] As explained above, in the core composition which uses the metal magnetism powder in which the insulating coat uniform [ the dust core of this invention ] and good was formed, it is proper flux density and highly efficient-ization that it is more than the specific resistance cm of 2ohms, i.e., low iron loss, is attained. Moreover, the manufacture method of this invention becomes certainly possible [ stabilizing and mass-producing ] from having solved the more exact process condition as compared with the former about a highly efficient dust core.

[Translation done.]

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**CLAIMS**

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**[Claim(s)]**

[Claim 1] It is the dust core for RFs characterized by the specific resistance which a dust core consists of 84% or more of the aforementioned metal magnetism powder and 1% of the weight or more of thermosetting resin by the volume ratio, and is obtained while the thickness of the aforementioned insulating coat formed in the front face of the aforementioned metal magnetism powder is 10nm or more and 100nm or less in the dust core using the metal magnetism powder which formed the insulating coat in the front face with phosphate chemical-conversion liquid, and thermosetting resin being more than 2-ohmcm.

[Claim 2] In the manufacture method of the dust core which carries out heat hardening while pressing, after mixing the metal magnetism powder which formed the insulating coat in the front face with the phosphate chemical-conversion liquid containing a surfactant, and thermosetting resin As the aforementioned metal magnetism powder, that by which 80% of the weight or more of use metal magnetism powder formed the aforementioned insulating coat in thickness (10nm or more and 100nm or less) is used. as mixed conditions The 1 % of the weight or more of the aforementioned thermosetting resin is mixed with the aforementioned metal magnetism powder. The manufacture method of the dust core for RFs characterized by specific resistance obtaining the dust core more than 2-ohmcm by adjusting the volume ratio in the dust core of the aforementioned metal magnetism powder as a process condition so that it may become 84% or more.

[Claim 3] The manufacture method of the dust core for RFs according to claim 2 that a mean particle diameter adds thermosetting resin powder 100 micrometers or less in 1 - 3% of the weight of the range to the aforementioned metal magnetism powder as the aforementioned thermosetting resin.

[Claim 4] The manufacture method of the dust core for RFs according to claim 3 that a rotational frequency mixes mixture with the aforementioned metal magnetism powder and the aforementioned thermosetting resin powder at least 45 minutes or more on condition that 15 - 35rpm using the V type and W cone type mixer which are usually used with powder-metallurgy processing.

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[Translation done.]

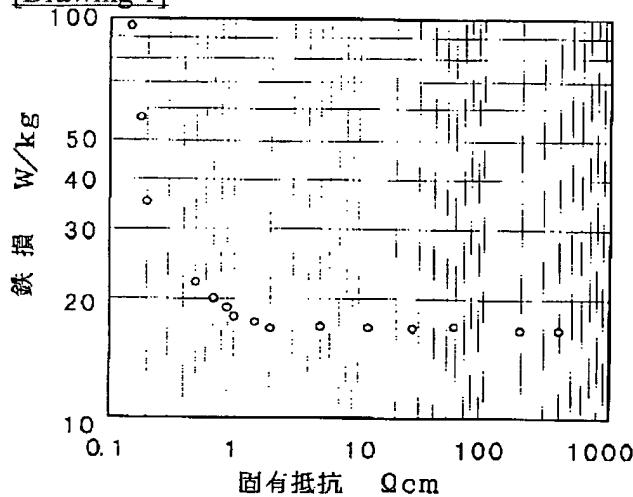
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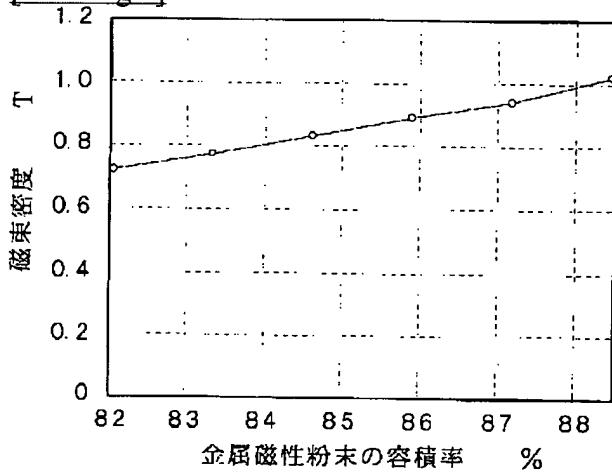
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## DRAWINGS

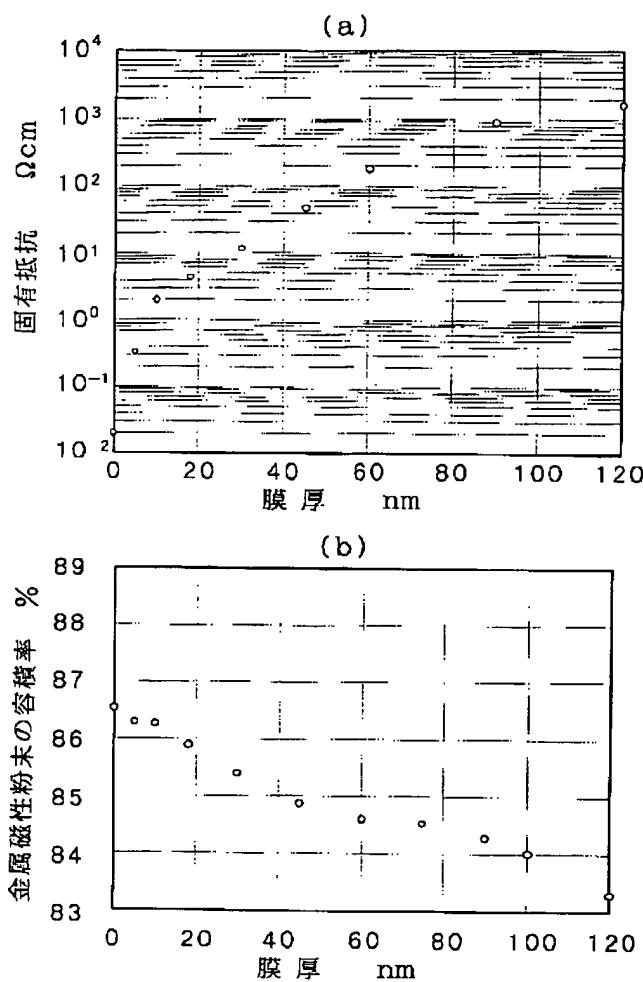
[Drawing 1]



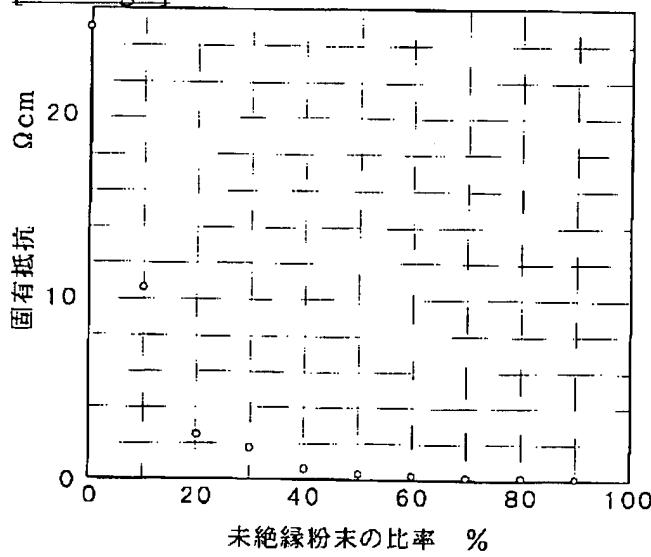
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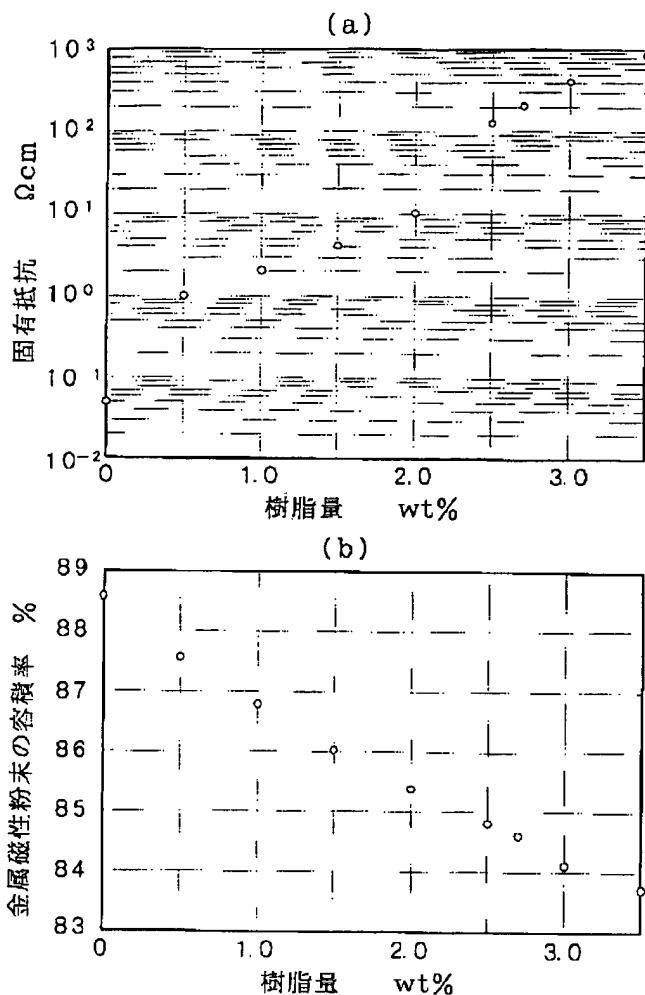
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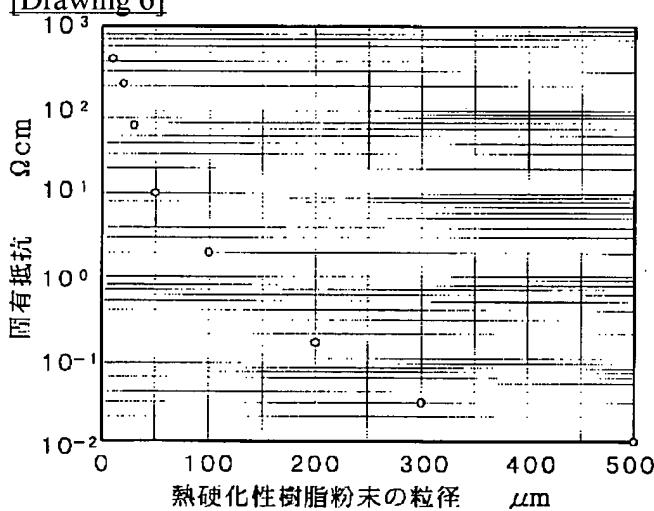
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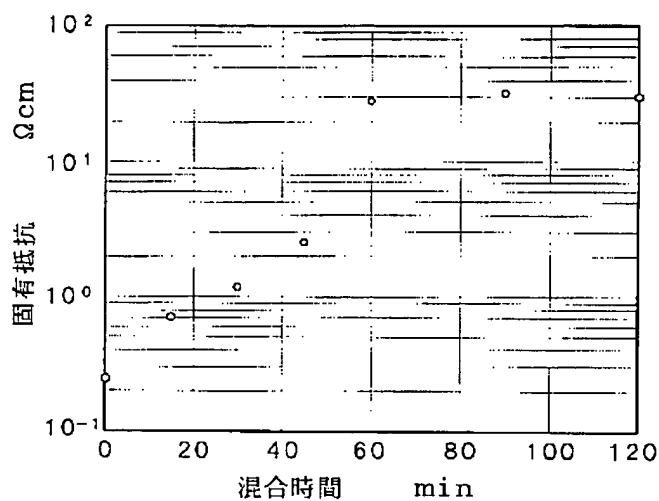
[Drawing 5]



[Drawing 6]



[Drawing 7]



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[Translation done.]

DERWENT-ACC-NO: 1999-576817

DERWENT-WEEK: 200001

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TITLE: Dust core for transformer, reactor, thyristor valve -  
has predetermined thickness of insulated film formed on  
metal magnetic powder which is blended with specific  
amount of thermosetting resin

PATENT-ASSIGNEE: HITACHI FUNMATSU YAKIN KK[HITU]

PRIORITY-DATA: 1998JP-0049124 (March 2, 1998)

PATENT-FAMILY:

PUB-NO MAIN-IPC	PUB-DATE	LANGUAGE	PAGES
JP 11251131 A 001/20	September 17, 1999	N/A	007 H01F

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
JP 11251131A	N/A	1998JP-0049124	March 2, 1998

INT-CL (IPC): B22F001/02, B22F003/00 , H01F001/20

ABSTRACTED-PUB-NO: JP 11251131A

BASIC-ABSTRACT:

NOVELTY - An insulated film of thickness 10-100 nm is formed on surface of about 80 weight % (wt. %) of metal magnetic powder using phosphate formation treatment liquid. The capacity ratio of metal magnetic powder is adjusted to 84% or more. About 1 wt% of thermosetting resin is blending with metal magnetic powder and molded to obtain dust core of specific resistance of 2 ohm cm<sup>2</sup> or more.

DETAILED DESCRIPTION - An INDEPENDENT CLAIM is also included for dust core

manufacturing method.

USE - For transformer, reactor, thyristor valve, noise film, coil, etc.

ADVANTAGE - Offers uniform formation of insulated film with less core loss.

CHOSEN-DRAWING: Dwg.1/7

TITLE-TERMS: DUST CORE TRANSFORMER REACTOR THYRISTOR VALVE  
PREDETERMINED THICK

INSULATE FILM FORMING METAL MAGNETIC POWDER BLEND  
SPECIFIC AMOUNT  
THERMOSETTING RESIN

DERWENT-CLASS: A85 L03 M22 P53 V02

CPI-CODES: A11-B05; A12-E04; A12-E08B; L03-B02A; M22-H03F;  
M22-H03G;

EPI-CODES: V02-A02A;

ENHANCED-POLYMER-INDEXING:

Polymer Index [1.1]

018 ; H0328 ; S9999 S1285\*R

Polymer Index [1.2]

018 ; ND01 ; Q9999 Q7374\*R Q7330 ; Q9999 Q7421\*R Q7330 ; B9999  
B3270

B3190 ; B9999 B5243\*R B4740

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: C1999-168078

Non-CPI Secondary Accession Numbers: N1999-425976